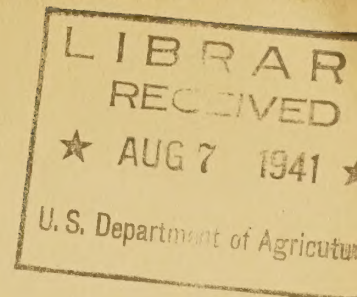


1.932
F2 H87

UNITED STATES DEPARTMENT OF AGRICULTURE
*U.S. Bureau of agricultural chemistry
and engineering.*

May 1941



Summary of Survey in the Wenatchee-~~Okanogan~~ District
of Washington

The detailed report from which this summary is made covers 63 cold storage plants. Five small plants which are not equipped to handle any appreciable quantity of Delicious are not included. A refrigerated ice storage at Apple Yard subject to use as an apple storage is not included.

There is cold storage space available in the district if fully occupied with boxes adequately spaced sufficient to hold 10,136 carloads of apples.

After making thermal corrections for building construction and motor losses, the refrigeration equipment in these plants has a total value of 2,166 net tons for cooling fruit. If used efficiently, this amount of refrigeration is sufficient to cool 364 cars of Delicious apples daily.

The total 1940 production of Delicious, Red Delicious, and Golden Delicious is estimated at 6,290 cars. Shipments from 1939 crop were 5,475 cars. This indicates that during a 14-day harvesting period the average daily picking of these varieties would be approximately 448 cars, but on peak days the amount might be twice this volume. Coincident with the season of Delicious harvest about 1,000 cars of Jonathan apples have been harvested, many of which are normally refrigerated, utilizing, of course, a part of the total net tonnage shown above.

The information on storage facilities is tabulated so that it may be broken down to give the situation for any locality or combination of localities desired.

SURVEY OF COLD STORAGE FACILITIES IN THE WENATCHEE- OKANOGAN APPLE PRODUCING DISTRICT

By W. V. Hukill, Senior Agricultural Engineer,
Bureau of Agricultural Chemistry and Engin-
eering, and Edwin Smith, Senior Horticulturist,
Bureau of Plant Industry, U. S. Department of
Agriculture.

Purpose

The economy of the apple industry of the Wenatchee-Okanogan area is predominantly dependent upon profitable returns from the Delicious variety, which with its red strains, accounts for about 40 percent of the apple production. To maintain the increasing tonnage of Delicious apples in favor with distributors and consumers, demands adequate refrigeration at the time of harvest and during storage. This survey was planned to furnish a detailed report on each cold storage plant in the district.^{1/} The storage space and refrigeration capacity of all

^{1/} Made in response to a request of the Interbureau Coordinating Committee on the Wenatchee-Okanogan Fruit Producing Area.

plants were items of prime importance in the survey. A knowledge of the available refrigeration and its distribution is a requisite to the most advantageous handling of the apple crop as a whole and of the more perishable varieties in particular.

Survey Procedure

The essential information to be obtained was listed in the form of a questionnaire, a copy of which is attached. Each storage plant was visited and the forms were filled in. Actual measurements of rooms and of equipment not otherwise described were made. The size, speed and other characteristics of equipment were recorded. The operating data were taken from statements of the manager or engineer or other operators. No attempt was made to go behind the estimate made by these persons regarding the operating practices unless there was an obvious inconsistency.

Presentation of Results

Individual capacity summaries of each plant have been prepared. These include the storage capacity, number of rooms, the refrigeration in terms of gross tons, building loss, motor loss and net tons for cooling fruit, and cooling capacity in terms of packed boxes, (a) when cooled as packed fruit, and (b) when cooled as loose fruit. These occasionally carry comments and may be used for informing interested parties as to the capacity of individual plants. A sample of the individual plant summaries is attached.

A tabulation, table 1, has been made showing fruit shipments, storage capacity, net tons of refrigeration, daily fruit cooling capacity, and estimated daily average volume of apples picked in local areas which fall within reasonable trucking radius, such as the Oroville-Ellisforde-Tonasket or the Omak-Okanogan-Malott districts.

Discussion of Results

From table 1 it is to be seen that the greatest volume of refrigeration is centered at Wenatchee where there is an apparent surplus for the volume of fruit in the immediate vicinity. Unfortunately data are not available showing the Delicious production in each locality. From interviews with storage operators it was indicated that some shipping points, having limited refrigeration facilities, had higher proportions of their receipts made up of Delicious, Red Delicious, and Golden Delicious than was the case in the vicinity immediately contributory to Wenatchee. This may be due either to the later planted areas such as Oroville, Ellisforde-Tonasket, actually producing a much higher proportion of Delicious than the other districts, or it may be due to the fact that Delicious are taken to local storages while less sensitive varieties such as the Winesap are shipped out for storage.

Excessive Loads

Interviews indicated that in most plants apples were received at the peak of the Delicious season in quantities very much greater than their cooling capacities.

This general condition of excessive receipts over cooling capacity indicates that, in many instances, weeks instead of days may have been required to cool the Delicious crop to 32° F. Most deficient in refrigeration for the crop to be handled are the Ertiat, Omak-Okanogan-Malott and Oroville-Ellisforde-Tonasket sections. Among individual shipping-points, Brewster is very short of refrigeration for its apple production, but in the next town, Pateros, only 7 miles away, the refrigeration capacity is more nearly adequate and somewhat makes up for the deficiency in the district as a whole.

Deficient Cooling Capacity:

Taken as a whole the refrigeration in the Wenatchee-Okanogan district at present is sufficient to cool Delicious apples at the rate of 364 cars daily.

The total 1940 production of Delicious, Red Delicious and Golden Delicious was estimated at 6,290 cars. Shipments from the 1939 crop amounted to 5,475 cars. During a 14-day harvesting period the average daily tonnage harvested would be approximately 448 cars. Coincident with the season of Delicious harvest about 1,000 cars of Jonathan apples have been harvested. Many of the Jonathan variety are normally refrigerated utilizing part of the cooling capacity of the district.

Table 1

Relation of cold storage and refrigeration capacity to apple production in different sections
March 1 - April 25, 1941

District	Production Est. 1940 Cars (1)	Cold storage space Cars	Net tons refrigeration	Daily cooling capacity Cars (2)	Estimated Ave. daily harvest Cars (3)
Oroville-Ellisforde-Tonasket	1338	676	144.0	24.0	37.1 A
Omak-Okanogan-Malott	1840	839	189.9	31.7	51.1
Brewster-Pateros-Monse	1375	866	187.1	31.2	38.1 A
Chelan-Chelan Falls-Azwell	2178	1698	320.9	56.1	60.5 A
Entiat-Ribbon Cliff-Wagnersburg	1381	399	96.1	16.0	38.4
Wenatchee-Olds	3674	3363	744.1	124.1	102.0
Monitor-Cashmere-Dryden	2435	1491	357.8	59.5	67.6
Peshastin-Leavenworth	865	804	126.1	21.0	24.1 A

(1) Wenatchee Valley Traffic Association.

(2) Based upon cooling packed boxes.

(3) Based upon 36 harvest days for entire apple crop. Considerably greater during the peak of the Delicious harvest.

A Survey indicated percentage of Delicious may have been greater than for the region as a whole.
No data are available on the Delicious production by districts.

This report on the survey considers only the refrigeration facilities as found supplemented with some data indicating the refrigeration needs for the proper handling of the Delicious apple crop.

The solution of the problem of providing additional refrigeration involves economic consideration of the industry as a whole and of the communities in which additional facilities may seem urgently needed.

SUGGESTIONS FOR CONSIDERATION

The following procedures for establishing the best use of facilities and for meeting the requirements of Delicious apples are suggested for consideration.

In the first place it seems advisable that a plan be adopted whereby the handling of the Delicious crop before and during storage would be coordinated in such a way that the facilities may be utilized to the best advantage. Such a plan would provide for combining the horticultural, engineering, and economic factors to take advantage of all possibilities for effective and economical improvements in practices. The requirements of the fruit have been established in a general way by the experimental work of the Bureau of Plant Industry. The present survey shows what facilities are available and how they are distributed, and may be used to determine where facilities might be expanded most economically. This leaves unanswered the questions of the cost per box of cooling and storing and of the increased economic returns to be expected on Delicious apples which have been properly refrigerated. These questions will have to be answered, at least tentatively, before a logical program of increasing storage facilities can be undertaken.

In view of the inadequacy of present facilities for taking care of the Delicious crops several plans appear promising for effective management of the storage problems. These include (1) reallocation of fruit to plants in the various localities, (2) earmarking long storage fruit, (3) handling Delicious preferentially, (4) storage at Eastern points, (5) cooling in refrigerator cars, (6) increasing cold storage facilities in the valley. No doubt several or all of these plans could be used together.

1. Reallocation of Fruit to Plants

The survey will show that some areas are better equipped to handle the normal Delicious crops than others. Apples from the points having the greatest shortage of storage capacity could be moved to other points. This would not, of course, relieve the situation as a whole but would make possible the best use of such facilities as are available. It would involve anticipating the amount of Delicious to be expected at each producing point and initiating new contacts between producing groups and warehouse operators.

2. Earmarking Long Storage Fruit

Apples which move into the market early in the season do not need as prompt cooling as those which are to be held for long periods, and those which move into consumption at harvest time need no precooling at all. To take advantage of this situation it would be necessary to know at harvest time which lots of fruit are to be held for long periods and which are to be shipped to market relatively early. These lots would be segregated and special attention would be given to properly cooling only the long-storage lots.

3. Handling Delicious Preferentially

The exclusion of better-keeping varieties from cold storage until the Delicious have been adequately cooled would make possible the use of the full refrigeration capacity on Delicious. The extent to which this could be practiced without too much penalty to other varieties would, of course, be worked out on the basis of the experience of the Bureau of Plant Industry relative to keeping qualities of the various varieties.

4. Eastern Storage

Insofar as the facilities for cooling apples adequately are not available in the producing area, refrigerated shipments to other parts of the country might take care of part of the crop. This would not necessarily be entirely satisfactory because of delays in loading and because the cooling might not be as rapid as would be desired, for long-keeping fruit, unless the fruit is precooled in the car, which could be done but at an added cost. It would, however, relieve the load on local storages. Storage of part of the surplus in Eastern cities might be considered a temporary solution until adequate facilities may be provided in the producing area.

5. Cooling in Refrigerator Cars

Arrangements might be made with the refrigerator car line to use iced cars as precooling rooms. The feasibility of this practice would depend upon the availability of refrigerator cars and an adequate and economic ice supply. It could be followed most economically where apples are moved from one shipping point to another within the district, as for instance, from Omak to Pateros, or from Brewster to Wenatchee. Cooling in iced cars normally proceeds at a relatively slow rate and it might be necessary to use precooling fans and to salt the bunker ice. It should be emphasised however, that precooling, to be beneficial, must result in the comparatively rapid cooling of the apples to a temperature of 31° or 32° F. preferably within 4 to 7 days. "Precooling" should not be interpreted as depending upon any particular sequence of operations in handling the fruit but rather as the rapid reduction of fruit temperature to the proper holding point.

6. Increasing Storage Facilities

If an economic analysis indicates that more storage facilities would be advisable the result of the survey should be used to determine the location and nature of the construction. There are some plants in which the addition of insulation would increase the cooling capacity and reduce operating costs. There are others in which the volume is large but the capacity for cooling apples is relatively small. In these, additional refrigerating machinery would bring the plant into better balance. If plants are to be remodeled or new ones built it would be advisable to obtain the services of a competent refrigerating engineer to act as consultant and help the builders to choose the proper items of expenditures for the greatest economic return. The detailed information obtained on the survey would, no doubt, be of value to such an engineer and this, as well as the summary contained in this report, will be made available if requested.

APPENDIX

Analysis of Records

The questionnaire included some items which were incidental to the main purpose of the survey. Answers to certain questions were obtainable in very few cases. For example, there were few records of temperatures of brine or cooling air. In a few cases no estimate of the ammonia pressures could be obtained.

Volume Capacity: The storage capacity of each cold storage room was computed from measurements taken at the plant. These measurements included inside dimensions and dimensions of obstruction to loading such as stairs, air-ducts, elevators, conveyors, etc. The aisle space normally used according to the statement of the operator or according to the aisle marks painted on the floors was allowed for. The height of stacking used in the computations was ordinarily as nearly as possible that actually used in the room. On the other hand, the spacing of boxes actually indicated by the operator was not necessarily used in the computation but a standard spacing which would give an equivalent of 2.2 cu. ft. per box was used, making an allowance for the usable space in each room. The box capacity was estimated by using a chart prepared by Homer J. Dana, Refrigeration Engineer of the Engineering Experiment Station at Washington State College. In some cases the computed box capacity was at considerable variance with the estimate of the operator.

There were rooms in some of the plants in which only partial cooling was applied either by blowing air from a regularly cooled room or by a small amount of direct expansion cooling surface. In general, the capacity of such rooms is not included in the summary.

Building Heat Loss: Records of the building construction and insulation appear on page 1 of the form. For each type of construction the conductance in B.t.u. per sq. ft. per 24 hours per degree was computed, using in most cases, the conductivity values found in the A.S.R.E. Data Book. The heat loss from walls was calculated using an outside temperature of 65° F. and an inside temperature of 32°. From roofs the outside temperature was taken as 75° and from floors on the ground 55° was used. For floors off the ground or ceilings under shaded areas 65° was used. A conductance of 3 B.t.u. per 24 hours per square foot per degree was used for concrete floors not insulated. If insulated the resistance of the insulating material was added to that corresponding to 3 B.t.u. conductance and the overall conductance computed in the conventional manner. It should be noted that the insulation in each case was assumed to have retained its original condition. No doubt, in some cases, this was not true and the building losses are actually higher than the calculated values. If further detailed studies are made of any of these plants, the condition of the insulation should be examined as carefully as the nature of the study may warrant. In general, the building losses reported are as low as may be expected and may be considerably too low in some cases.

Motor Loss: The refrigeration load due to the operation of brine pumps and fans is included as Motor Loss. The heat generated by other motors, by lights, and by the men working in the plant as well as the heat entering from air infiltration was not deducted directly in determining the net refrigeration available. These loads were assumed to be dependent largely on the amount of fruit taken in and were accounted for by using a high refrigeration requirement per box of fruit.

Refrigeration Capacity: The reported dimensions and speed of the compressors, were used to compute the theoretical displacement. The actual displacement in these computations was assumed to be 80 percent of the theoretical. The amount of refrigeration per cu. ft. per minute, was estimated on the basis of the reported ammonia pressures during the fall. The net tons of refrigeration available for cooling fruit is the difference between the gross capacity of the machines and the sum of the Building and Motor Losses.

Fruit Load: Delicious apples must be placed in cold storage promptly after picking and the temperature of the fruit should be reduced to 32° F. within 7 days after storage. For long storage periods more rapid cooling is desirable, but when packed fruit is stored, one week is a practical cooling period upon which to base computations and is one which will give satisfactory results for a normal marketing season. It has been assumed that the apples received into the storage rooms will be at an average temperature of 65°. Including the sensible (field) heat and the heat generated through respiration while cooling from 65° to 32° in a week, it is estimated that each box of apples requires 2,000 B.t.u. refrigeration. This is equivalent to 6.95 tons per 1,000 packed boxes. For the purpose of this calculation, the refrigeration requirement has been increased to 8 tons per 1,000 boxes to take care of infiltration and other losses incidental to storing the fruit.

The above fruit load is for fruit packed before placing in storage. When apples are cooled while loose in boxes before packing, there will be an additional refrigeration requirement. In this case not only must the volume of culls be cooled but there also will be additional cooling because the fruit warms up a few degrees when removed for washing and packing. The reduction in heat generated by respiration when cooling loose fruit in 3 days approximately offsets the normal heat taken up in washing and packing. Based upon an estimated 20 percent cullage in Delicious in 1940, it has been assumed that the additional refrigeration requirement for cooling unpacked fruit will be about 25 percent. That is, fruit cooled while loose will require about 10 tons of refrigeration instead of 8 tons per 1,000 packed boxes.

Items Covered in Individual Summaries
of Plants

STORAGE CAPACITY. The capacity for a given plant was based upon spacing boxes for Delicious storage which gave an equivalent of 2.2 cu. ft. per box, making an allowance for the usable space in each room. Although the capacity allowed for the usual aisles and lost space, no allowance was made for loss of space due to odd lots which frequently may occur where all lots have to be accessible for removal.

REFRIGERATION. The gross tons of refrigeration were calculated from the displacement of the compressors and the reported ammonia pressures during the Delicious receiving period. The building loss was based upon a mean outside temperature of 65° F., with 10° higher for roof and 10° lower for ground exposure. Variations in building loss will apply, due to weather differences of localities and seasons and also where insulation is found not to be in good condition. The net tons of refrigeration for cooling fruit included a margin for heat factors such as open doors, lights, conveyor motors and workmen. These losses were based upon the number of boxes stored, and were accounted for by using a high refrigeration requirement per box of fruit.

COOLING CAPACITY. These values, given in terms of packed boxes which may be received each 24 hours, were based upon apples at 65°F. being cooled throughout to 32° in 3 days when loose, or in 7 days, when packed. The loss of refrigeration through washing and packing loose-cooled fruit is approximately offset by the smaller amount of heat of respiration when cooling takes place in three days instead of seven. The net loss in cooling loose apples largely hinges upon the percentage of culls. In these computations an arbitrary cullage of 20 percent was used. This is a variable associated with local conditions and individual plants will have cooling capacities greater or less than the figures given depending upon such factors, which include temperatures during harvest and efficiency in plant operation.

Sample of Individual Summaries of Plants

Town _____, Wash.

Name of Plant _____

Storage Capacity 192

Number of Rooms 10

Refrigeration

Gross tons 77

Building loss 7.1

Motor loss 8.2

Net tons 61.7

Cooling Capacity	In Packed Boxes	In Cars
If cooled packed	7,700	10.2
If cooled loose	6,170	8.2

On account of Room 3 not being insulated this room should not be refrigerated until after the Delicious Season. This would save between 3 and 4 tons refrigeration or sufficient to cool about 500 additional boxes per day.

Survey Questionnaire

COLD STORAGE AND PRECOOLING SURVEY

Plant _____

Place _____ Date _____

Contact _____

Railroad siding. Yes _____ No _____

Dimensions of building _____

Stories _____

Wall construction

Roof construction

Floor construction

Normal receipt into storage per day Loose _____ Packed _____

Number of storage rooms _____

Condition of building (notes)

Note other uses of building including ice making capacity, lockers, etc.

Plant

Storage rooms

Number

Location

Dimensions

Exposed area

Aisle space

Other encumbrances

Normal capacity, boxes

Normal spacing

Height of stack

Storage temperature

Type of cooling

Openings, doors

Openings, windows

Fans in room, No.

Power, all

Air delivery, location, size

Air return, location, size

Distance del. to ret. ft.

Cooling coils, size

" " length

" " number

" " location

Thermometers

Plant _____

General air equipment _____

Size of ducts, length _____

Air cooled by _____

Fans - power _____

Manufacturer _____

Mfg. type _____

Actual speed _____

Pressure at fan (log) _____

Air temperature in _____

" " out _____

Brine equipment _____

Pumps, H. P. _____

Cooling surface _____

Brine temperature to coils (log) _____

return (log) _____

Plant _____

Compressors Number _____

Installed by _____

Manufacturer _____

Type No. _____

No. cylinders _____

Cylinder dimension _____

Actual speed _____

Power, H. P. _____

Type drive _____

Discharge pressure (log) _____

Suction pressure (log) _____

Receiver capacity _____

How used (standby, etc.) _____

Pressure safety devices _____

Condenser

Type _____

Source of cooling _____

Water temp. in (log) _____

Water temp. out (log) _____

Description of condenser including cooling surface

Other equipment

Portable fans, ozonator, etc.

Plant _____

Packing Plant

Annual packout (by varieties) _____

Washers, number _____

" type _____

solution notes

Graders, number _____

type _____

Type of lighting _____

Peak daily capacity _____

Usual daily capacity _____

Arrangement for packing cold fruit. Yes _____ No _____

Note unusual conditions _____

General

Season of operation _____

Total shipments _____

Shipments of warm fruit _____

Rates _____

1871

1872

1873

1874

1875

1876

1877

1878

1879

1880

1881

1882

1883

1884

1885

1886

1887

1888

1889

1890